MOONBOUNCE OPERATING AIDS

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Four "moonbounce" operating aids are included in this collection of EME notes. They are: 1)- An EME Path Loss Nomogram, 2)- An EME Operating Chart, 3)- Universal EME Window Chart for USA and Europe, and 4)- Reprint of a QST article on Noise Behind the Moon.

1- An EME Path Loss Nomogram (figure 1)

The nomogram was calculated by Joe Reisert, W6FZJ. It shows the change in path loss for the six "moonbounce" bands as the moon travels from perigee to apogee. "Sky and Telescope" magazine gives the distance to the moon and the dates for perigee and apogee. The semi-diameter (SD) of the moon is given in the "Nautical Almanac" on the right-hand pages at the bottom left.

The semi-diameter is half the moon diameter and is given in minutes of arc. The larger the SD number, the closer the moon is to the earth and therefore the lower the path loss. Scheduling for an EME contact at apogee could end in failure for systems which are marginal, as the 2 decibel difference in signal strength at apogee could "use up" all the signal-to-noise margin of the circuit.

2- EME Operating Chart (figure 2)

This chart has proven useful in keeping track of what has been sent and copied during an EME schedule. The operator can quickly determine whether he should be transmitting or listening at a given time within the schedule. After a series of schedules early in the morning, the operator usually needs help in keeping things straight! The chart will do the job.

The chart shown is made up for a California station scheduling Europe, Australia or the eastern USA. East coast operators will need two charts, one for working west and the other for working Europe.

3- Universal EME Window Chart for USA and Europe (figure 3)

Many experimenters have suggested that a Universal EME Window Chart be established for each of the bands used for moonbounce contacts, the argument being that a fixed array could be erected, pointing towards the window. Such an array could be built close to the ground, eliminating high towers and complicated aiming systems. In addition, it would not be hindered by trees and buildings if properly placed, would be easy to maintain and (hopefully) would not offend the neighbors.

Stations using a fixed array and the Universal EME Window could work each other via the Window, as well as other stations using steerable antennas.

In all probability, the well-equipped tropo station could not use the Window as he cannot raise his array to the proper angle of elevation. But these stations could, as they are now doing, work the steerable EME stations and others near the same Longitude who are using the rising or setting moon. The ultimate answer, of course, is for all experimenters to have antennas steerable in both azimuth and elevation to some degree.

While it is impossible to have a Universal EME Window to satisfy all continents, I propose a Universal Window for 144 MHz work between USA and Europe be chosen. Such a Window is illustrated in the graph, calculated for a setting moon in Germany. Various locations in the USA could point to this Window using the typical azimuth and elevation data in the table of figure 4 to aim a fixed array.

The table indicates that if an array with a sharp pattern is used, some steering will be required to hit the entire Window. If the array is not steerable, then the last one-half hour of the Window should be favored in order to work Europe. The table suggests the antenna should have a broad azimuth pattern and a sharp vertical pattern because of the small change in elevation required during a one hour schedule.

4- Noise Behind the Moon

The following reprint of the article "Sky Temperature Behind the Moon" (QST, October, 1964) is of interest to the serious moonbouncer. There are times when the moon is in front of a noisy part of the sky and during these periods the echos returning to earth from the moon can be completely masked by the noise. This would prevent a contact from being made, without an apparent reason for the failure.

The magazine "Sky and Telescope" has a map showing the moon's path across the sky for each month. By knowing the location of the strong celestial radio frequency sources, an operator can avoid scheduling on days when chances of success are low. Generally speaking, if the moonbounce schedule is held to periods when the moon has a north declination, the chances of success are enhanced, as the moon is in a "quiet" area of the sky. Southern declinations have a high probability of being noisy.

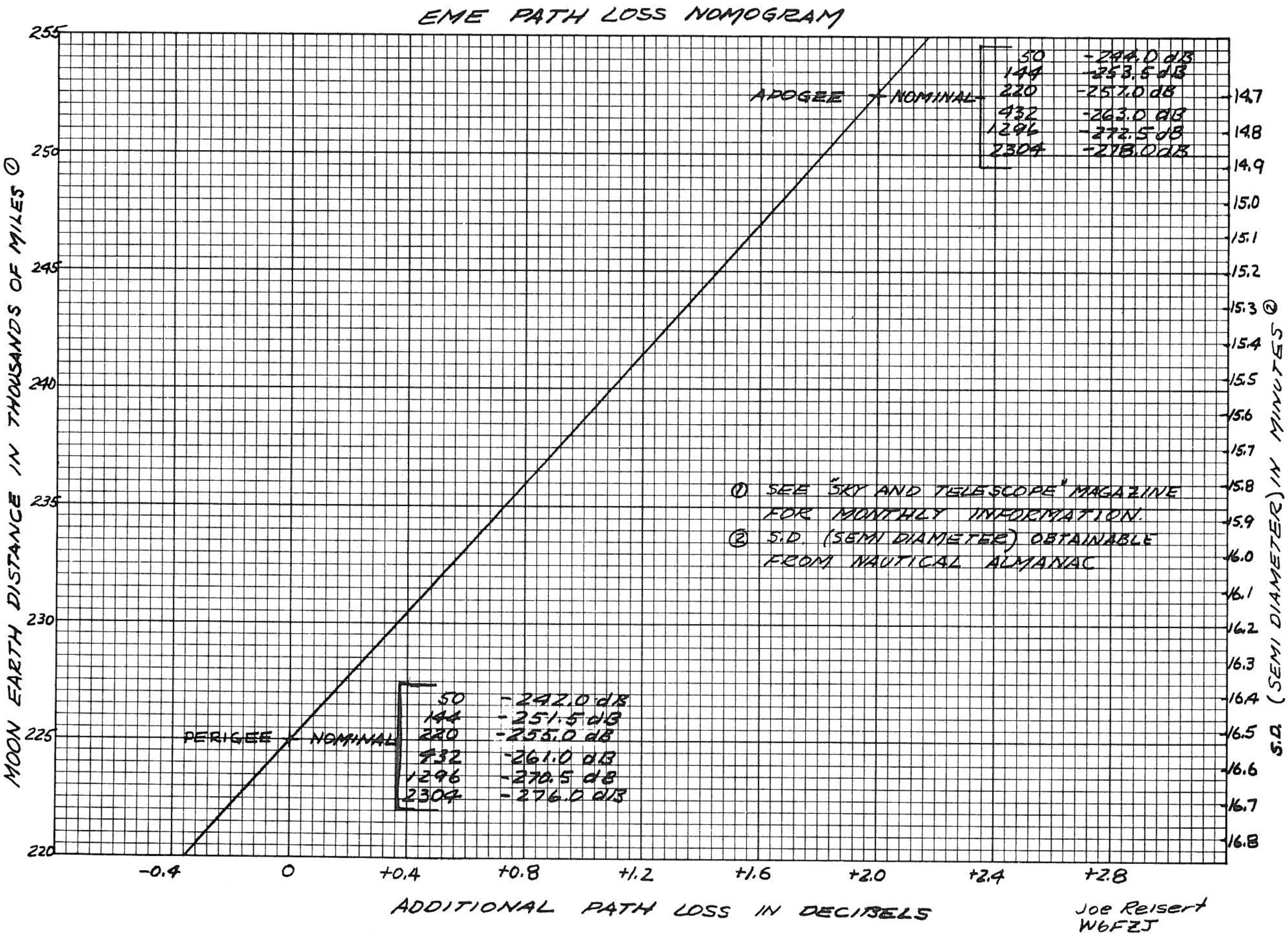
EME PATH LOSS NOMOGRAM
MOON EARTH DISTANCE IN THOUSANDS OF MILES ①
255
250
245
240
235
230
225
220
S.D. (SEMI DIAMETER) IN MINUTES ②
14.7
14.8
14.9
15.0
15.1
15.2
15.3
15.4
15.5
15.6
15.7
15.8
15.9
16.0
16.1
16.2
16.3
16.4
16.5
16.6
16.7
16.8
ADDITIONAL PATH LOSS IN DECIBELS
-0.4
0
+0.4
+0.8
+1.2
+1.6
+2.0
+2.4
+2.8
APOGEE
NOMINAL
50 -244.0 dB
144 -253.5 dB
220 -257.0 dB
432 -263.0 dB
1296 -272.5 dB
2304 -278.0 dB
PERIGEE
NOMINAL
50 -242.0 dB
144 -251.5 dB
220 -255.0 dB
432 -261.0 dB
1296 -270.5 dB
2304 -276.0 dB
① SEE "SKY AND TELESCOPE" MAGAZINE FOR MONTHLY INFORMATION.
② S.D. (SEMI DIAMETER) OBTAINABLE FROM NAUTICAL ALMANAC
Joe Reisert
W6FZJ

FIG. 1

DATE ____________________ STATION ____________________

TIME __________ GMT __________ NOISE ____________________

0 -- 2 RECV	30 -- 32 XMIT
2 -- 4 XMIT	32 -- 34 RECV
4 -- 6 RECV	34 -- 36 XMIT
6 -- 8 XMIT	36 -- 38 RECV
8 -- 10 RECV	38 -- 40 XMIT
10 -- 12 XMIT	40 -- 42 RECV
12 -- 14 RECV	42 -- 44 XMIT
14 -- 16 XMIT	44 -- 46 RECV
16 -- 18 RECV	46 -- 48 XMIT
18 -- 20 XMIT	48 -- 50 RECV
20 -- 22 RECV	50 -- 52 XMIT
22 -- 24 XMIT	52 -- 54 RECV
24 -- 26 RECV	54 -- 56 XMIT
26 -- 28 XMIT	56 -- 58 RECV
28 -- 30 RECV	58 -- 60 XMIT

FIG. 2

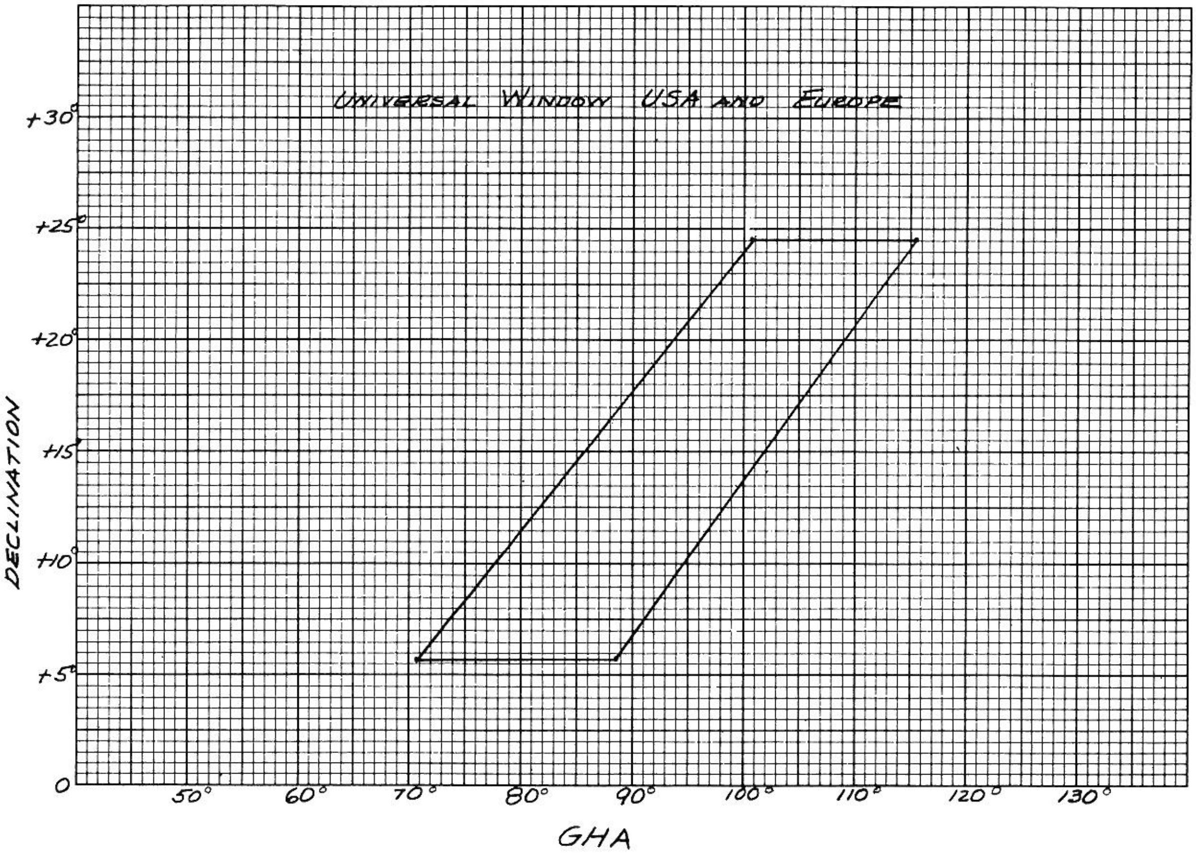

FIG. 3

TYPICAL ELEVATION AND AZIMUTH DATA
TO HIT PROPOSED UNIVERSAL WINDOW
AT VARIOUS GEOGRAPHIC LOCATIONS

Date	GMT	Seattle, Washington		Nashua, New Hampshire		San Mateo, California		Minneapolis, Minnesota		Frankfurt, Germany	
		El (°)	Az (°)	El (°)	Az (°)	El (°)	Az (°)	El (°)	Az (°)	El (°)	Az (°)
7/17/73	0700-0812	28-37	117-131	52-51	179-202	32-43	111-124	45-50	147-167	11-0	265-276
7/18/73	0830-0930	39-46	123-145	57-50	191-226	44-56	115-136	54-55	159-191	8-0	277-286
7/19/73	0945-1045	47-54	126-145	60-52	212-234	52-62	116-134	60-60	168-197	8-0	284-294
7/21/73	1220-1332	60-65	137-164	58-46	240-259	66-75	122-167	67-59	198-232	7-0	297-305
7/22/73	1330-1432	61-66	136-164	59-47	242-260	67-76	119-166	68-61	199-234	7-0	300-308
7/25/73	1550-1650	52-57	130-147	59-53	224-240	58-65	115-135	63-61	172-202	7-0	288-298
7/26/73	1615-1715	43-50	120-141	59-48	203-235	47-61	114-143	57-56	162-201	9-0	280-290
7/27/73	1635-1735	35-41	122-133	55-50	191-214	40-49	115-130	50-53	155-179	9-0	270-282

FIG. 4

Sky Temperature Behind the Moon

BY C. R. SOMERLOCK,* W3WCP

IT IS common knowledge that if an antenna is pointed at the sky, it will receive radio noise. This noise is generated chiefly by our galaxy, the milky way. The intensity of the emissions will, of course, depend on the particular part of the sky at which the antenna is pointed; the "hottest" direction being that of the galactic center ($\alpha = 17^h 43^m$, $\delta = -28.8°$.).

If, now, one desires to communicate with some object that is silhouetted against the sky, and whose position in the sky changes, it is important to know the background sky temperature in the vicinity of that object. (The "temperature" is a measure of the radiated noise power.) In a situation such as an amateur v.h.f. moonbounce attempt, this information can make the difference between success and failure.

Method

To obtain the data, the position of the moon was determined (in equatorial coordinates) from *The American Ephemeris and Nautical Almanac* for 12 noon each day of the month of December 1965. These positions were then converted into galactic coordinates with the aid of appropriate coordinate conversion table.[1] Knowing the position of the moon in galactic coordinates allowed the background sky "temperature" to be read from a radio map of the galaxy. The particular one used was plotted by Baldwin[2] at 81 Mc. using a beamwidth of 2 by 15 degrees.

Since the moon's precession rate is small, the gross features of the data are valid for a year or so. Because the data vary in a periodic manner, similar plots can be made for any desired month in this valid period simply by shifting the abscissa of the curve by a multiple of one lunar orbital period (about 27¼ days). The values can also be extrapolated to other frequencies by the approximate formula:

$$T_x = T_o \left(\frac{f_o}{f_x}\right)^{2.7}$$

While the details of the radio sky may vary with frequency somewhat, the main features will not change.

Results

The end result of all this work is the curve shown in Fig. 1, plotting background sky temperature behind the moon for 144 Mc. Note that for about 3 days out of the month the moon is passing directly across the center of the Milky Way, resulting in very high noise temperatures in the antenna beam. As an example of what effect this can have on 2-meter moonbounce communications, consider the following case:

Bandwidth = 1 kc.
Preamplifier noise figure = 2 db.
Sky temperature = 400° K.
Received signal = −140 dbm.

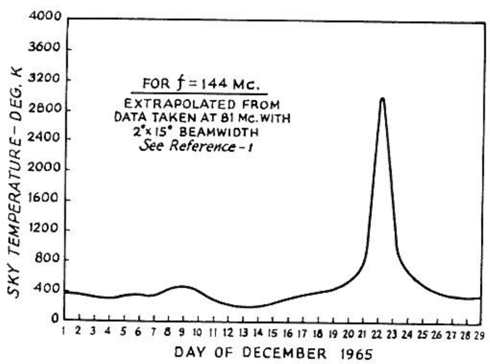

Fig. 1—Background sky temperature behind the moon, for December, 1965, for the 144-Mc. band.

The noise figure can be converted to an equivalent noise "temperature" by the relation:

$$T = 290\ (N\text{-}1) \text{ degrees Kelvin}$$

where N is the noise *factor*. The sky radiation can then be added directly to this preamp noise temperature, since they have the same effect and are in the same units. The total noise can then be converted back to more familiar units of power by:

$$\text{Noise power} = KTB$$

where: $K = 1.6 \times 10^{-23}$ = Boltzman's Constant
T = sky temp. + pre-amp temp.
B = system bandwidth

Under these conditions, the noise power is computed as being −142 dbm, and the received signal-to-noise ratio will be:

$$S/N = +2 \text{ db.}$$

Table I

Frequency Conversion Factors

For a Freq. of:	Divide Values of Curve by:
50 Mc.	0.058
144	1.00
220	3.15
430	19.3
1296	380

Now consider what happens if the same system is used when the moon is in front of the galactic center. In this case:

Sky temperature = 3000° K,
so Noise power = KTB = −133 dbm.

The signal, however, is still only −140 dbm, so the received signal-to-noise ratio under these conditions has dropped to −7 db. This kind of variation can easily make the difference between success and failure.

Values for other frequencies can be determined by dividing readings from Fig. 1 by the appropriate factor from Table I, showing the relative noise strengths for various amateur bands. Clearly the problem lessens with increased frequency, and becomes negligible at 1296Mc.

Table II gives a list of approximate dates of future noise maxima which should be avoided for v.h.f. moonbounce attempts, unless the system is designed to handle these conditions. QST

Table II

Dates of Noise Maxima for a Moon-Tracking Antenna.

1964	1965
July 27	Jan. 1
August 23	Jan. 28
September 20	Feb. 25
October 17	March 24
November 13	April 21
December 10	May 18
	June 14
	July 11
	August 8
	September 4
	October 1
	October 29
	November 25
	December 22

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* NASA, Goddard Space Flight Center, Greenbelt, Maryland 20771.

1 Annals of the Lund Observatory, No. 15, 16, 17

2 Baldwin, J. E. — "A survey of the Integrated Radio Emission at a Wavelength of 3.7M.", Monthly Notices of the Royal Astronomical Society *115*, Pages 684–689.